INDICATORS OF THE NEUROLOGICAL STATUS OF COGNITIVE IMPAIRMENT IN POSTTRAUMATIC ENCEPHALOPATHY IN CHILDREN

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Abstract*. The article presents the results of a survey of 46 children aged 7 to 18 years with a diagnosis of post-traumatic encephalopathy. The examination and assessment of the neurological status were carried out according to a generally accepted method. To determine the severity of the headache, a visual analog scale (VAS) was used, the study of cognitive function was carried out according to the Schulte table and the Luria test. All patients underwent routine EEG, and 20 patients underwent MRI*
Keywords*: traumatic brain injury, post-traumatic encephalopathy, electroencephalography, magnetic resonance imaging, transcranial dopplerography*

Introduction. Recently, there has been an increase in injuries worldwide, among which traumatic brain injuries (TBI) account for up to 4% of all injuries [13, 14; 21]. TBI is particularly dangerous for children and adolescents, given the relatively high prevalence among them, as well as various consequences that occur both in the acute and long-term period.

Special attention should be paid not only to medical problems of TBI, but also to social ones, since complications and consequences of TBI are one of the main causes of childhood disability, while children under 5 years old and from 15 to 18 years old are at special risk, since TBI occurs most often at this age [11].

The clinical manifestations of the effects of TBI may be different, but the defeat of GM in the form of post-traumatic encephalopathy, which is a dynamic process and has a progressive character, comes out in the first place [5, 7, 24, 25]

The clinical picture of TBI is formed by primary and secondary lesions of the central nervous system. The primary lesion is a lesion of the brain, in which necrosis is formed with subsequent death of nerve cells and neuroglia, vascular lesion with further thrombosis. On the other hand, secondary damage is formed as a result of the initiation of a malfunction of intracellular metabolism, the launch of excitotoxicity processes and a cascade of lipid peroxidation, the formation of free radicals.

At the same time, as a result of the transferred TBI, two oppositely directed, but at the same time interacting with each other processes are launched: degenerative-destructive and regenerative-reparative. The predominance (constant or for a certain period of time) of each of these processes for the most part forms the development and absence of certain clinical manifestations in the long term.

TBI [15]. Special attention in studying this interaction is paid to various specific proteins involved in intracellular neuroregulation – neurotrophic factors, the deficiency of which leads to the predominance of destructive mechanisms and disruption of regenerative mechanisms with the subsequent development of neurological deficiency, the severity of which is also due to adaptation mechanisms: the plasticity of the central nervous system and its morphofunctional reserves [19].

The plasticity of the central nervous system can be called the process of biological adaptation, which is based on the structural and functional restructuring of the nervous system. The main purpose of activating neuroplasticity is to restore brain functions that are impaired or lost due to injury [4]. With the help of reparative neuroplasticity, it is possible to restore the functional systems of the brain that have suffered as a result of damage.

This happens by stimulating intact synapses, as well as a result of the so-called phenomenon of synaptic sprouting, as a result of which neosynaptogenesis is activated and the growth of nerve processes occurs. An additional favorable environment for this is created by the fact that the plasticity of the brain in children is better than in adults, therefore, a favorable outcome can be expected in children more often, even in cases of severe TBI

The number of cases with moderate and severe TBI is approximately 10-25% and they mostly have adverse consequences for the further normal development of children and show a negative impact on the further development of children [13; 18]

At the same time, among children who had TBI without detecting skull fractures and who did not have any focal neurostatus disorders during the acute course of TBI, various long-term consequences may develop. At the same time, even minor injuries suffered by children and adolescents do not always go away favorably, and their complications may manifest years after TBI [11, 22].

Due to the fact that there is a lesion of the brain, which has not yet been fully formed, a plastic transformation of the brain occurs, which requires time to recover, as a result of which the peculiar course of post-traumatic encephalopathy will affect the development of the child's personality, psycho-emotional background, his cognitive abilities and the formation of social skills.

In the long-term period of TBI, functions can either fully recover, or the clinical process can progress, while its duration during clinical recovery can reach 2 years, and in the case of disease progression is not limited and as a result, a separate nosological category is formed in the form of traumatic brain disease [13].

There is an opinion that the development of the clinical picture of the consequences of TBI is due to long-term disorders in the regulation of blood circulation and vascular tone, which arose as a result chronic disorders of the cerebral hemodynamic system [16]. Cerebrospinal fluid disorders are directly related to vascular disorders, being one of the pathological processes that contribute to the formation of complications in the long-term period of TBI. In this case, the choroidal plexuses are affected, which results in a violation of the regulation of cerebrospinal fluid production and its resorption after a TBI. There are also other changes affecting the microcirculatory bed of the brain: these are cerebral venous dyscirculation and fibrosis of the meninges. All this contributes to the development of disorders of cerebrospinal fluid dynamics, which are expressed in the form of a violation of intracranial pressure.

During the development of TBI in children in the long term, the following symptoms are noted: headache, fatigue, emotional instability, irritability, anxiety, tearfulness, sleep disorders.

A number of studies [1, 17, 23] have revealed a relationship between the severity of TBI and the severity of clinical, cognitive and psychoemotional disorders in the long-term period of TBI. At the same time, it should be noted that, despite the severity of TBI, about half of children in the long-term period of TBI develop neurological disorders that lead to significant functional disorders.

In his work [12], A.I. Kemalov described that in children aged 4 to 14 years, complications occur in the period from 6 months to 4 years after moderate and severe TBI. Almost all of these children have discoordination disorders, about 90% have asthenic complaints, about 3/4 of the children have memory and attention disorders (while 15% of children may have speech disorders). Chronic headaches in children were also very often noted, which, due to their prevalence and influence, deserve special attention.

Chronic post-traumatic headaches are one of the most frequent complaints in patients in the long-term period, and according to A. I. Kemalov, they are observed in 90-95% of children with TBI. Headache may have a different character and severity, but it should be correlated with the presence of a history of TBI by the time of its occurrence or intensification. Most often, it has similarities in clinical manifestations corresponding to primary headaches, such as migraine – 46.5%, GBH – 24.8% of children and other types, while in 19% of cases the pain is not classified.

According to experts [6], most often, chronic headaches are a consequence of mild TBI, they can worsen after a certain period, which can be months or years, and also tend to progress in the long term after its occurrence. One of the common causes of chronic post-traumatic headaches is the impact of socio-psychological factors, especially in patients with mild TBI, as well as the uncontrolled use of various analgesic drugs.

According to the work of A.V. Goryunova [8], children with the consequences of TBI in 76% of cases have various disorders in the psycho-emotional and volitional sphere, which is one of the predisposing conditions for the formation of pain syndrome and its transition to the category of chronic.

In addition to headaches, it is necessary to pay attention to cognitive disorders, since in addition to medical significance, they have a great impact on the quality of life and their development in the long-term period of TBI can lead to difficulties in school, as well as to social maladaptation [9, 10, 22].

Most often, there is a violation of mnestic functions (including auditory, visual and kinesthetic memory), attention retention and distribution functions, as well as a violation of the speed of various cognitive functions [9, 10]. As a result, a child with TBI experiences a slowdown in intellectual activity and difficulties when working with a large amount of information [11, 28] and, as a result, school performance suffers, which is why children often have neurasthenic disorders and emotional disorders when returning to school and the social circle.

Thus, the prevalence of TBI among children, progressive neurological deficits, the complexity of diagnosis and the lack of objective criteria for assessing increasing functional disorders, the severity of the consequences affecting the processes of formation of the child's body with subsequent disability, puts this pathology in a number of priority medical and social problems [25-27].

In this regard, we conducted a study to study the anamnestic, clinical, neurological, neurophysiological, and features of post-traumatic encephalopathy.

Materials and methods

We conducted a study of the clinical picture of 46 children from 7 to 18 with a diagnosis of post-traumatic encephalopathy with a TBI duration of at least 2 years, divided into 2 groups. Group I consisted of 20 children (10 boys and 10 girls) with mild TBI consequences, with an average age of 13.2 ± 4.5 (95%CI: 10.9–15.2) years. Group II included 26 children (15 boys and 11 girls) with the effects of moderate TBI, whose average age was 11.6 ± 3.4 (95%CI: 9.5–13.7) years.

The examination and assessment of the neurological status were carried out according to a generally accepted method. The nature of headache in the examined patients was determined on the basis of the International Headache Classification (2003). A visual analog scale (VAS) was used to determine the severity of the headache. The study of cognitive function was carried out using a modified version of the single-color Schulte tables and a 10-word memorization test using the method of A.R. Luria.

All patients underwent a routine EEG performed for 20 minutes, and 20 patients underwent MRI. The obtained results were processed using parametric and nonparametric statistical methods (the Excel application software package).

The results of the study

The study of the structure of TBI depending on gender and age (Table 1) showed that at the age of 11-14 years in both groups, the incidence of both mild and moderate TBI was lower, and TBI was more common in boys than in girls. However, as we can see, there was no statistical difference between the groups.

Table 1

Distribution of patients by age and gender

	All		Group I		Group II		P
	n	%	n	%	n	%	
Sex							
Boys	25	54,3	10	50	15	57,7	0,604
Girls	21	45,7	10	50	11	42,3	
Age							
7–10 age	18	39,1	6	30	12	30	0,499
11–14 age	11	23,9	5	25	6	25	
15–18 age	17	37,0	9	45	8	45	

The nature of patients' complaints is of great importance due to the high sensitivity of the subjective state of children to various brain disorders. According to their structure, the complaints presented in both groups were practically the same, the differences were in severity and frequency of occurrence by age (tab. 12.)

The table shows that children most often reported headache – 35 (76.1%) patients, while in the group with moderate TBI and in the group with lung, the figures were approximately the same 75-76%. Attention disorders, irritability and fatigue occurred in approximately the same number of cases, 67-69%, Memory impairment occurred in 28 (60.9%) children, and the difference between the group with mild and moderate TBI was more pronounced (55% and 65.4%, respectively). Dizziness was also significantly more common in the group with moderate severity – 50% of cases, in the group with mild – 35%. It should also be noted (from anamnestic data) that the above symptoms tended to increase with age and the prescription period of the injury. In pediatric

neurological practice, the main and decisive standard of diagnosis is the conduct and analysis of the neurological status (Table 3), and, if necessary, additional paraclinical examination methods.

Table 2

Characteristics of the main complaints of patients (%)

Indicators	Diagnosis		p
	Group I	Group II	
Dizziness	7 (35,0)	13 (50,0)	0,309
Headache	15 (75,0)	20 (76,9)	1,000
Memory disorders	11 (55,0)	17 (65,4)	0,474
Attention disorders	12 (60,0)	20 (76,9)	0,333
Rapid fatigue	15 (75,0)	16 (61,5)	0,365
Irritability	13 (65,0)	19 (73,1)	0,748

Table 3

Neurostatus data

Symptoms	All		Group I		Group II		P
	n	%	n	%	n	%	
Nystagmus	20	43,5	6	30	14	53,8	p>0,05
The soreness of T. Valle	38	82,6	15	75	23	88,5	p>0,05
Muscle hypotension	21	45,7	10	50	11	42,3	p>0,05
Hyper- reflection	43	93,5	18	90	25	96,2	p>0,05
Instability of P. Romberg	24	52,2	10	50	14	53,8	p>0,05
PNP intention	27	58,7	12	60	15	57,7	p>0,05
The Danzig- Kunkov symptom	39	84,8	15	75	24	92,3	p>0,05
Adiadochokinesis	13	28,3	6	30	7	26,9	p>0,05
Sensitive disorders	23	50	7	35	16	61,5	p>0,05

According to the results of the neurological examination, it was seen that in children with posttraumatic encephalopathy, microsymptomatics in the form of increased tendon reflexes (93.5%), Danzing-Kunakov's symptom – 84.8%, and T. soreness prevailed relatively. Valle – 82.5%. Discoordination disorders in the form of instability in the Romberg pose and errors in performing coordination tests were found in 52.2% and 58.7%, respectively, and nystagmus and adiodochokinesis – 43.5% and 28.3%.

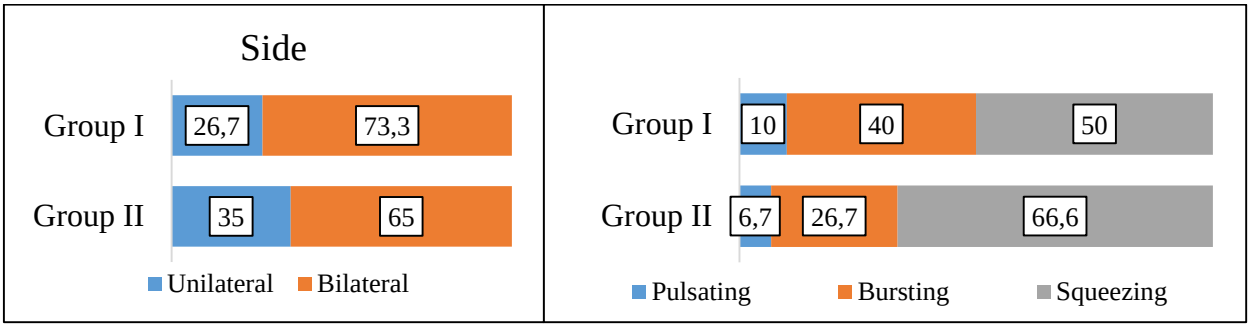
Reliable and relative indicators in both subgroups of patients with mild and moderate TBI consequences did not differ from each other. In general, violations were most often found in the group with the consequences of moderate TBI, significant differences were observed in the analysis of sensitive disorders. When analyzing neurostatus depending on gender and age, it was revealed that mild microsymptomatics prevailed in young children in both groups, regardless of gender, coordination disorders signify. So, according to the neurostatus data, it follows that, with few exceptions, the general disorders in the two groups were similar.

Due to the fact that the main problem for children who had TBI was headache, we conducted additional research on headaches. The results of the peculiarities of the subjective "coloring" of post-traumatic GB showed that the nature of various types of cephalgia can be noted in the consequences of TBI.

Headache was observed in the majority of patients of both groups who suffered TBI – 76.9% in the group with moderate and 75.0% in the group with mild course. The structure of

cephalgic syndrome was dominated by bilateral GB (73.3% and 65% in the group with concussion and bruise, respectively), in some cases, the pain in the head was severe and reverberated in the frontal-parietal, temporal-cervical or occipital-cervical regions, sometimes it spread to the face, temples and shoulders, which is explained by tension the muscles of the neck and head, which are strengthened by emotional stress, are mostly predominant in the afternoon. Unilateral headache was slightly more common in patients with a history of bruising – 35% of children.

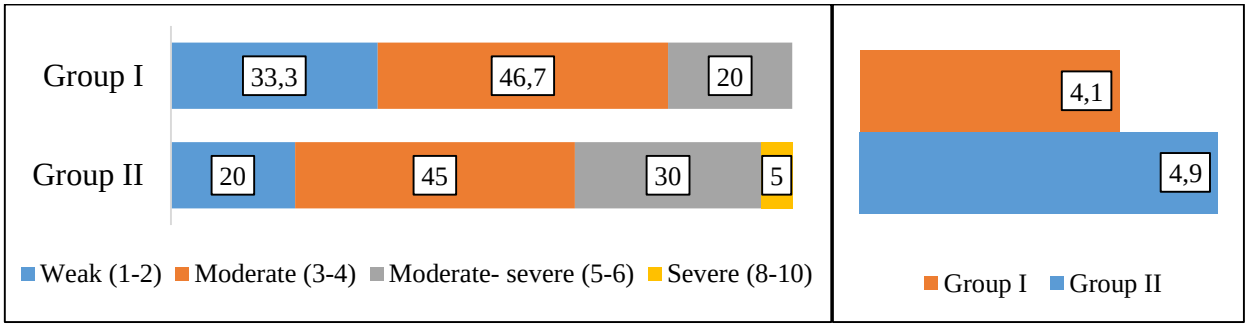
When assessing the nature of GB (Fig. 1), as we see in both groups, dull, aching, squeezing pains (such as helmets or vises) were most often observed, often on both sides. This type corresponded more to tension headaches and in the group with moderate TBI, 66,6%, and with easy – 50%



Pic. 1. Characteristics of headache (%)

The bursting nature of GB was significantly higher in patients with in the first group – 40.0% than in group II patients (26.7%), while it was most often located in the occiput and radiated to the eye socket, temple and forehead, neck and shoulder girdle. In 1 (6.7%) patient of group II and 2 (10.0%) in group I, the following character of GB was revealed: paroxysmal pain localized in the frontal-temporal region and in the eye socket, more often on the one hand, having a pulsating character and moderately strong intensity, accompanied by nausea, intolerance to light and strong sounds.

The results of headache intensity in patients with TBI consequences are shown in Figure 2. On average, the severity of GB varied from 2 to 8 points and averaged 4.9± 1.3 points in group II, and 4.1±0.7 points in group I. As can be seen from the table, regardless of the structure of GB, there were significantly more complaints of moderate headache in groups I and II – 46.7% and 45%, respectively.



Pic. 2. Severity of headache according to VAS (%)

Less often, patients complained of mild and severe pain, in the group of children with moderate-severe TBI, moderate–severe and severe pain were more often observed - 30% and 5%, whereas in the group with mild TBI, moderately severe was observed in 20%, and severe was not encountered. At the same time, mild pain was most often observed in children of group II – 33.3%.

The results of our study indicate the predominance of cephalgic syndrome in the consequences of TBI, GB similar to tension headaches and migraine-like pains.

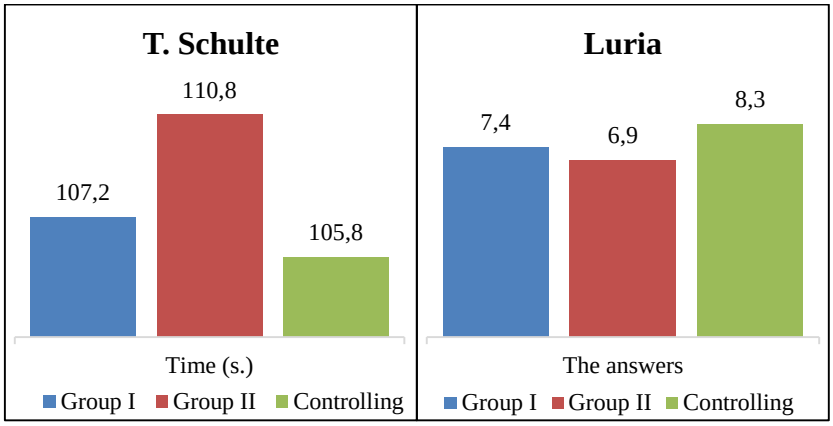
To study cognitive impairment, children were divided into 3 groups depending on school age, the distribution of which can be considered in detail in Table 4.

Table 4

Distribution of patients

Categories	Total gender		Sex			Diagnosis		
	Abs.	%	M	F	P	Group I	Group II	P
Junior	18	39,1	55,6	44,4	0,336	6 (33,3)	12 (66,7)	0,499
Average	11	23,9	36,4	63,6		5 (45,5)	6 (54,5)	
Older	17	37,0	64,7	35,3		9 (52,9)	8 (47,1)	

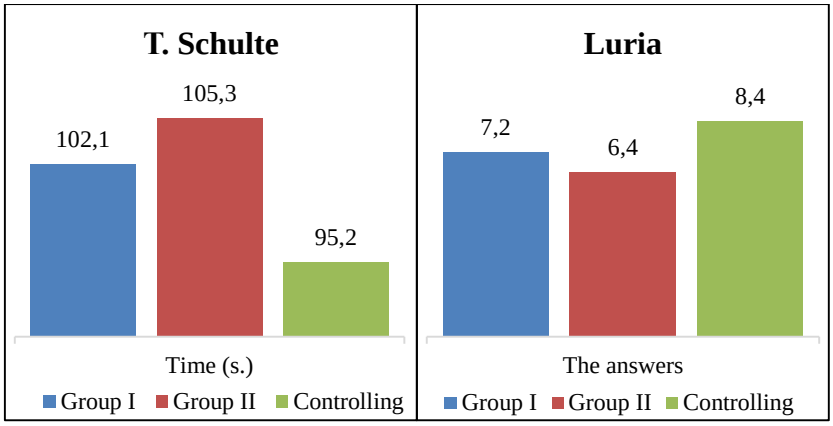
The study of cognitive function testing data in children in the primary school age group showed that significant differences between the indicators of mental activity in these children were not statistically significant and practically did not differ from those of healthy schoolchildren. The most significant differences were found during the study of the speed and volume characteristics of attention, as well as psychomotor activity.



Pic. 3. Characteristics of the function of attention and memory in primary school children

When studying the psychomotor reaction, the time indicators in children with the consequences of TBI were longer than relatively healthy schoolchildren, which manifested itself in the form of a slowdown in reaction and impaired coordination of movements, especially when performing complex actions. The average time during the study according to the test characterizing impaired concentration also prevailed in patients with the consequences of TBI ($p < 0.05$). The total execution time of the Schulte test, which reflects the amount of attention, was on average 109.1±35.2 seconds in the group of children with TBI compared with 105.8±24.7 ms in healthy children. The number of points in the Luria test, a memory parameter, was 7.2±2.3 and 8.3±1.1 in patients and healthy people, respectively. When comparing children with mild and moderate TBI, in this age group, memory indicators did not differ significantly between them, the difference was more significant only when conducting an attention study, the average time of T. Schulte in children with the effects of mild TBI was 107.2± 29.3 seconds, which was slightly higher than the control group, whereas in the group with the consequences of moderate TBI – 110.8±38.3 s. and the difference was significant both with group I and with healthy children.

When comparing the test results in the middle-aged group, differences in speed and volume indicators of cognitive functions were also revealed.

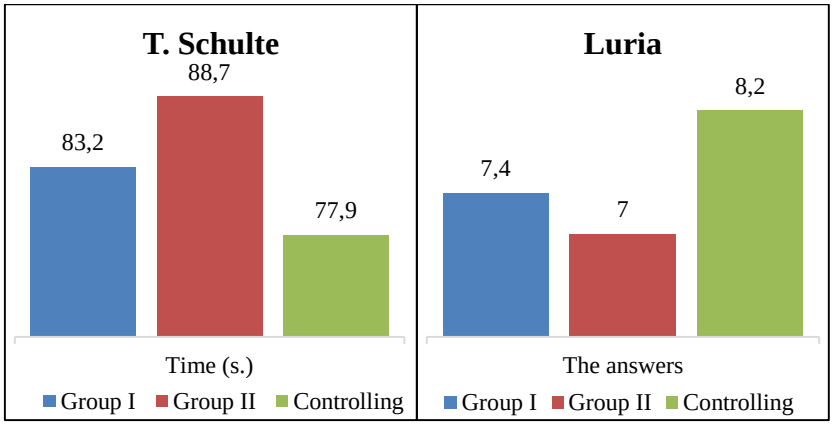


Pic. 4 Characteristics of the function of attention and memory in children of secondary school age

When studying the attention indicators, significant differences were found in the total time of the Schulte test – 103.7±39.3 in the group of patients compared with 95.2±24.2 s in the control group ($p < 0.05$). When analyzing memory indicators using the Luria test, deterioration was noted in patients with the consequences of TBI. On average, the test result of children with TBI consequences was 6.8±2.1 points, which was significantly lower than that of children in the control group (8.4 ± 1.1 points), and when comparing groups depending on the severity of TBI, the indicator in the group with moderate TBI (6.4± 2.3 points) significantly differed from the indicators in the group with mild TBI (7.2± 1.5 points). Thus, the relationship between the severity of TBI and impaired memory and attention functions in the middle school age group has been established.

The study of the test results in a group of high school children revealed significant differences in both speed and volume indicators of all cognitive functions (Fig. 5). Thus, in the study of attention in children. children with the consequences of TBI were found to have a violation of its volume

When assessing the function of attention, a significant increase in the total duration was found during the Schulte Test in the group with the consequences of TBI ($p < 0.05$). There were also differences when comparing children with mild and moderate TBI. In the group with mild TBI consequences, the average test execution time was 82.2±34.1 seconds, and in the group with an average degree – 89.7±37.9 seconds, the differences with both healthy and between groups were significant ($p < 0.05$).



Pic. 5 Characteristics of the function of attention and memory in children of senior school age

The analysis of memory volume during the Luria test showed significant differences between children with TBI consequences and healthy children – 7.2±2.3 points versus 8.2±1.1

points, respectively ($p < 0.05$). An assessment of the direct effect of TBI severity on the severity of mnestic functions did not reveal significant differences.

Analyzing our results, we can say that the severity of cognitive dysfunction is related to the severity of TBI and has differences in age groups. Attention disorders occur in all age groups, but are more pronounced in adolescents.

Conclusions

Thus, according to the results of our study, it can be concluded that children with the consequences of TBI are characterized by a different spectrum of disorders, the main of which are headache, cerebroasthenic and cognitive disorders. Headache manifests itself in the type of GBN and migraine, more often bilateral and moderate intensity. Cognitive impairments differ in different age groups, and perceptual impairments were more often observed in young children, whereas in the group of adolescents disorders of attention, memory and analytical-synthetic processes prevailed. The severity of cognitive impairment depends on the severity of TBI, the results of cognitive tests in the group of children with the consequences of moderate TBI were significantly worse than in the group with the consequences of mild TBI.

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